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# First Permian Ostracode Fauna from the Arabian Plate (Khuff Formation, Sultanate of Oman)

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**ABSTRACT:** Permian ostracodes of the Arabian Peninsula are recorded for the first time. Thirty five species from the marine Khuff Formation (Middle Permian) in Oman are presented here. Eleven species are new: *Bairdia omanensis* Crasquin-Soleau n. sp., *Cavellina huqfensis* Crasquin-Soleau n. sp., *Cavellina gerryi* Crasquin-Soleau n. sp., *Cavellina boomeri* Crasquin-Soleau n. sp., *Sulcella arabica* Crasquin-Soleau n. sp., *Langaia hornei* Crasquin-Soleau n. sp., *Sargentina woutersi* Crasquin-Soleau n. sp., *Carinaknightina braccinii* Crasquin-Soleau n. sp., *Jordanites lordi* Crasquin-Soleau n. sp., *Hollinella* (*Hollinella*) *benzartiae* Crasquin-Soleau n. sp., *Hollinella* (*Hollinella*) *martensi* Crasquin-Soleau n. sp.

Nine species are attributed to described species, and the age given is Middle Permian. Brachiopods and accompanying conodonts and foraminifera give a lower Wordian (Middle Permian) age (Angiolini et al. 1996, 1998).

The paleoecological analysis shows that the Khuff Formation was deposited in a very shallow marine, sublittoral environment under action of waves. The analysis of the relationships between the storm levels and the composition of the ostracode assemblage is in progress, even if in first approximation, the strong variations of compositions don't seemed to be linked with this phenomenon.

The paleobiogeographic relationships are strong with the Russian Platform, the North American platform and the South China. This could be explained by the importance of the surface current from East to West in the Paleo-Tethys realm.

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## INTRODUCTION

Two expeditions were held in Oman, in January 1995 and February 1997, on the Permian succession of the Huqf area as part of the International Peri-Tethys Programme. Paleontology and sedimentology of continental and marine series were investigated. We present here the ostracode fauna from the marine Khuff Formation obtained on the samples of the first expedition. The formation is dated as lower Wordian (lower Murgabian in Tethys scale, see table 1) using brachiopods and accompanying conodonts and foraminifera (Angiolini et al. 1996).

## GEOLOGICAL SETTING

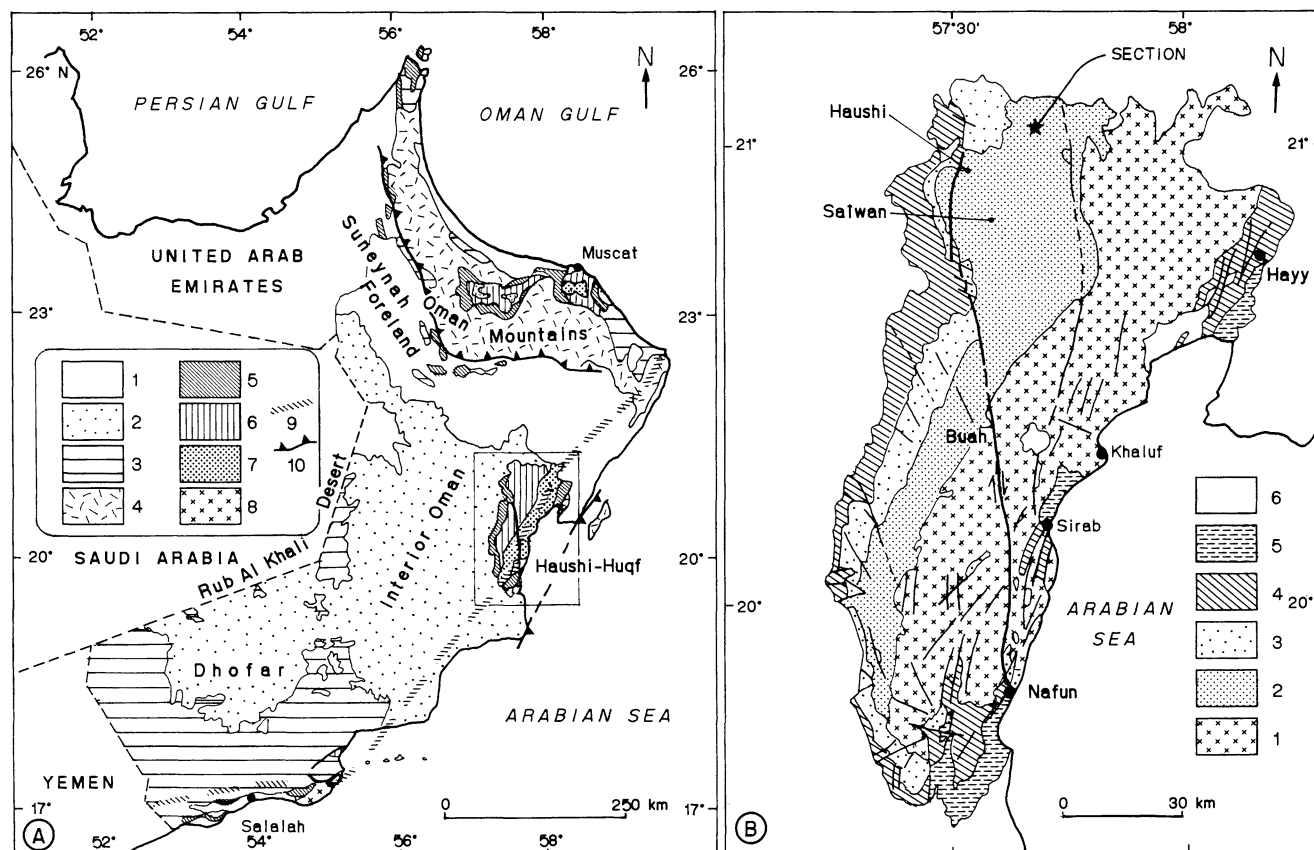
The Huqf area is located at the southeastern margin of the Arabian Plate in central Oman (text-fig. 1) and constitutes an anticlinal structure that exposes a Paleozoic sequence (Hughes-Clarke 1988). Late Carboniferous to Permian units form a north-south elongate strip exposed on the western edge of the uplifted Huqf massif (Le Métour et al. 1993). Subsurface data indicate steep

westward plunging of these units in the direction of the Rub al Khali basin.

The exposed late Paleozoic terranes of the Huqf area, which constitute the outcrop equivalent of the adjacent subsurface reservoirs, had long provided a privileged study field for petroleum geologists (unpublished PDO field guide and published first 1: 250 000 scale geological map in 1986). Nevertheless, stratigraphy of the late Paleozoic units was mainly established from subsurface data, drilled by numerous wells related to the presence of hydrocarbons in the Permian-Carboniferous reservoirs (Hughes-Clarke 1988).

During the 1: 250 000 scale geological mapping of Oman led in 1990-1991 by BRGM (Bureau de Recherches Géologiques et Minières, France) geologists, a revision of surface data was undertaken (Le Métour et al. 1993).

The nomenclature of the late Paleozoic succession, as described by petroleum geologists (see Hughes-Clarke 1988), comprises a



TEXT-FIGURE 1

Location map.

A - Simplified geological map of Oman (after Platel et al. 1994).

1. Quaternary; 2. Oligo-Miocene; 3. Paleocene-Eocene; 4. Samail ophiolite nappe and Hawasina nappes; 5. Dhofar: Cretaceous, Huqf: Late Cretaceous, Oman Mountains: Jurassic-Cretaceous; 6. Permian - Triassic to early Cretaceous; 7. Precambrian - Paleozoic; 8. Crystalline/metamorphic basement; 9. Huqf - Dhofar high; 10. Thrust front.

B - Geological sketch map of Haushi-Huqf area (after Platel et al. 1994).

1. Proterozoic - Lower Paleozoic; 2. Upper Paleozoic; 3. Triassic to Cenomanian; 4. Campano-Maastrichtian; 5. Paleocene - Eocene; 6. Miocene and Quaternary.

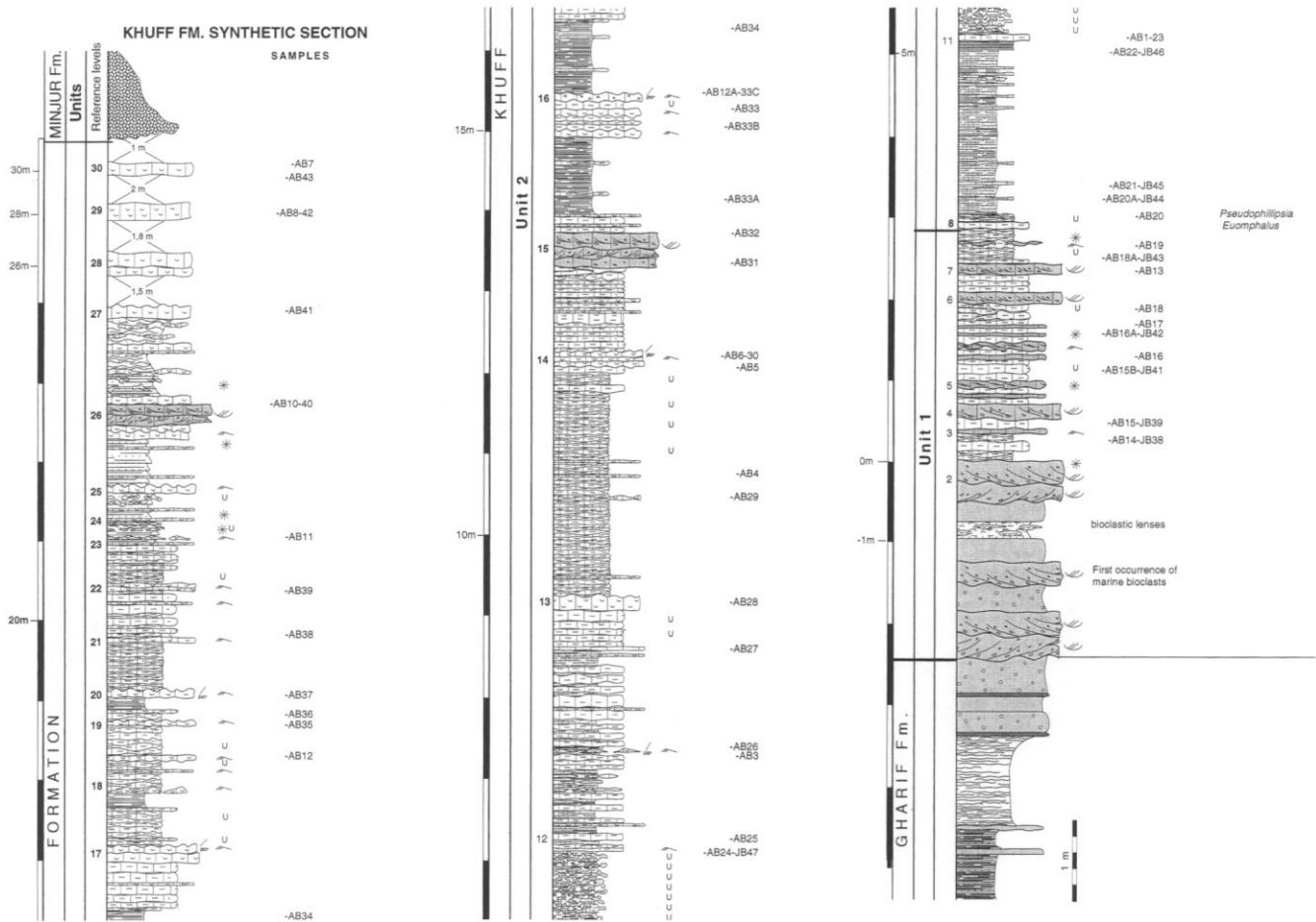
threefold division consisting of the Al Khlata Formation, the Gharif Formation and the Khuff Formation. In the course of the geological mapping program, BRGM geologists added a fourth unit, the Early Permian Saiwan Formation (Le Métour et al. 1993).

The outcrop succession records two stacked megasequences separated by a regional unconformity visible at the surface (Dubreuilh, Bécheu et al. 1992; Dubreuilh, Platel et al. 1992; Roger, Chevrel et al. 1992; Roger, Platel et al. 1992). The first begins with the Wesphalian to Sakmarian glacial-lacustrine deposits of the Al Khlata Formation, overlain by the transgressive marine sediments of the Artinskian Saiwan Formation (previously lower member of the Gharif Formation as defined by petroleum geologists and later raised to the rank of formation, Dubreuilh, Platel et al. 1992), marking the progressive deglaciation of the region. The most recent data indicate slightly older age, Sakmarian, for the Saiwan Formation (Angiolini et al. 1996, 1997), based on the brachiopod associations. The unconformable second megasequence encompasses the basal, thick, fluvial-terrigeneous Gharif Formation (restricted

here to the middle and upper members of the former Gharif Formation) for which the age is established as Artinskian-lower Wordian (Broutin et al. 1995). The sequence terminates with the marine, marly-carbonate deposits of the Khuff Formation, of which only the Middle Permian part is exposed under the Triassic to Jurassic unconformity. Recent age determinations (Angiolini et al. 1996), based on brachiopods, conodonts, foraminifera, and bivalves indicate of its lower Wordian age.

The Khuff Formation reference section studied is a composite section. The base occurs south-east of a flexural fault (GPS location N21°02'11", E57°41'23") and the top, along a more northern wadi entrenchment (GPS location N21°02'26", E57°41'13").

The exposed Middle Permian marine succession overlies a sharp, planar, flooding surface, which truncates the Gharif Formation clastic beds. It comprises a basal-bioturbated and slightly fossiliferous terrigenous unit (about 3 meters thick), followed by a 30 meter thick, marly-carbonate series (text-fig. 2). The Khuff Formation presents a characteristic lithologic succes-



TEXT-FIGURE 2

Synthetic section of the Khuff Formation (N21°02' - E57°41') (after Angiolini et al. 1998) with location of samples.

sion with only minor variations. Two informal units are distinguished in the Khuff Formation:

-The lower unit, about 6 meters thick, records a terrigenous clastic input, which decreases quickly in the upper half. The member begins with bedded, coarse- to medium-grained argillaceous sandstone (about 3 meters thick). Strongly bioturbated, these beds contain the first marine fauna (brachiopods, corals, crinoids, fishes). They are overlain by very fossiliferous, white to grey mudstones intercalated with dm-thick sandstone layers and subordinate grainstones with wave ripples.

-The second unit, 27 meters thick, which is limited at its top by an erosion surface, under the alterites of the (Lower Jurassic?) Minjur Formation, shows a marl-carbonate sedimentation. Thinly-bedded mudstone, which constitutes the more representative facies is intersected by numerous grainstone beds with wave ripples. Two characteristic burrowed horizons with lateral extension are recognized. Marly facies are recorded mainly at the base and in the upper half of this unit. Except at the base of the formation, the interbeds of grainstones and sandstones contain a diversified rich faunal association, different in composition from those of the marly-mudstone beds. Graded sand beds

with sharp bases and some intraclasts are interpreted as storm deposits that have been secondarily rippled by wave action (Angiolini et al. in prep.).

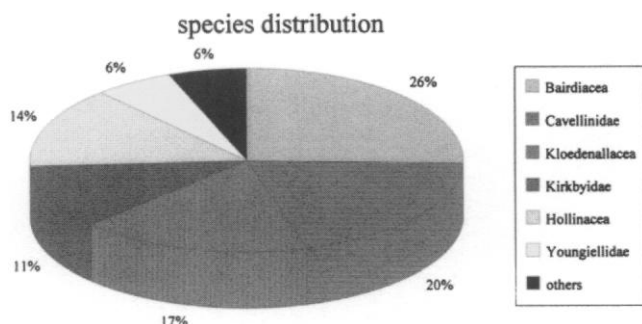
## SYSTEMATIC PALEONTOLOGY

Sixty-five samples were treated by hot acetolysis (Lethiers and Crasquin-Soleau 1988) of which fifty-five yielded ostracodes.

Thirty-five species belonging to 18 genera were identified and are figured, and eleven new species are described. All the specimens are deposited in the collections (number: MGL) of the Geological Museum of Lausanne (Switzerland). In the systematic descriptions the following abbreviations are used:

L: length, H: height, L1: anterior lobe; S1: anterior sulcus; L2: median lobe, S2: median sulcus, L3: posterior lobe, ACA: anterior cardinal angle, PCA: posterior cardinal angle.

The percentages of height are given from the dorsal border, and the percentages of length are given from the anterior border.



TEXT-FIGURE 3

Distribution of ostracode species in percentage of families or superfamilies in the Khuff Formation.

Order PALAEOCOPIIDA Henningmoen 1953  
Suborder KLOEDENELLOCOPIINA Scott 1961 emend.  
Lethiers 1978  
Superfamily KLOEDENELLACEA Ulrich and Bassler 1908  
? Family KNOXITIDAE Egorov 1950  
Genus *Langdaia* Wang 1978

***Langdaia hornei* Crasquin-Soleau n. sp.**

Plate 1, figures 1-3

**Etymology:** Dedicated to Dr. David Horne, University of Greenwich, Great Britain.

**Holotype:** One complete carapace, figured plate 1, figure 1, collection number MGL74651.

**Paratype:** One complete carapace, figured plate 1, figure 2, collection number MGL74652.

**Type level:** Sample JB43, upper part of lower unit of Khuff Formation, central Oman, Middle Permian (lower Wordian).

**Diagnosis:** Species of *Langdaia* with deep, narrow S2 located in upper half of height, diffuse reticulation organized parallel to ventral and dorsal margins.

**Description:** Dorsal margin straight and long; anterior margin straight in dorsal part, rounded in ventral part, maximum convexity located at mid-height; ventral margin long and straight; posterior margin with small radius of curvature, maximum convexity located at 32% of height; cardinal angles well-expressed (ACA= 120°, PCA= 130°); deep, narrow sulcus (S2) located in upper half of height and at mid-length; maximum height located at 35% of length; diffuse anastomosing ridges organized parallel to dorsal and ventral margins, resembling reticulation.

**Remarks:** The genus *Langdaia* was described from the Lower Triassic of South China by Wang (1978). The present occurrence extends the record of the genus to Middle Permian (lower Wordian).

*Langdaia hornei* Crasquin-Soleau n. sp. looks like *Langdaia suboblunga* Wang 1978, type species of the genus, but here the ACA is more acute, the S2 seems to be located in a more central

position and Wang did not note ornamentation in the original description.

**Size:** L= 0.81 to 0.87mm; H= 0.38 to 0.41mm.

**Distribution:** Khuff Formation (samples JB43, see table 2), Huqf area, central Oman, Middle Permian (lower Wordian).

Superfamily SANSABELLACEA Sohn 1961  
Family SERENIDIDAE Rozhdesvenskaya 1972  
Genus *Sargentina* Coryell and Johnson 1939

***Sargentina woutersi* Crasquin-Soleau n. sp.**

Plate 3, figures 9-12

**Etymology:** Dedicated to Dr. Karel Wouters, Royal Belgium Institute of Natural Sciences, Brussels, Belgium.

**Holotype:** One complete carapace, figured plate 3, figure 10, collection number MGL74694.

**Paratype:** One complete carapace, figured plate 3, figure 11, collection number MGL74695.

**Type level:** Sample AB16A, upper part of lower unit of Khuff Formation, central Oman, Middle Permian (lower Wordian).

**Diagnosis:** Species of *Sargentina* with a very shallow sulcus, anterior margin with maximum convexity located very ventrally; carapace flattened at anterior and posterior margins.

**Description:** Carapace with strong overlap of right valve on left; left valve: dorsal margin nearly straight, cardinal angles well-developed, posterior margin rounded, ventral margin nearly straight, anterior margin with small radius of curvature, valve flattened laterally all around the margins; right valve: dorsal margin gently convex, posterior margin rounded with maximum convexity located at 35% of height, ventral margin straight, anterior margin with very small radius of curvature, maximum convexity located between 63 and 72% of height; cardinal angles poorly sharp; shallow sulcus in median part of the carapace; maximum height located at 30% of length; surface smooth.

**Remarks:** The general outline of the carapace resembles *Sargentina transitia* (Kozur 1985) from the lower Abadehian of Hungary, but here only a shallow sulcus is developed.

**Size:** L= 1.17 to 1.37mm; H= 0.68 to 0.75mm.

**Distribution:** Khuff Formation (samples AB15 to AB7, see table 2), Huqf area, central Oman, Middle Permian (lower Wordian).

Suborder KIRKBYOCOPINA Gründel 1969  
Superfamily KIRKBYACEA Ulrich and Bassler 1906  
Family KIRKBYIDAE Ulrich and Bassler 1906  
Genus *Carinaknightina* Sohn 1970

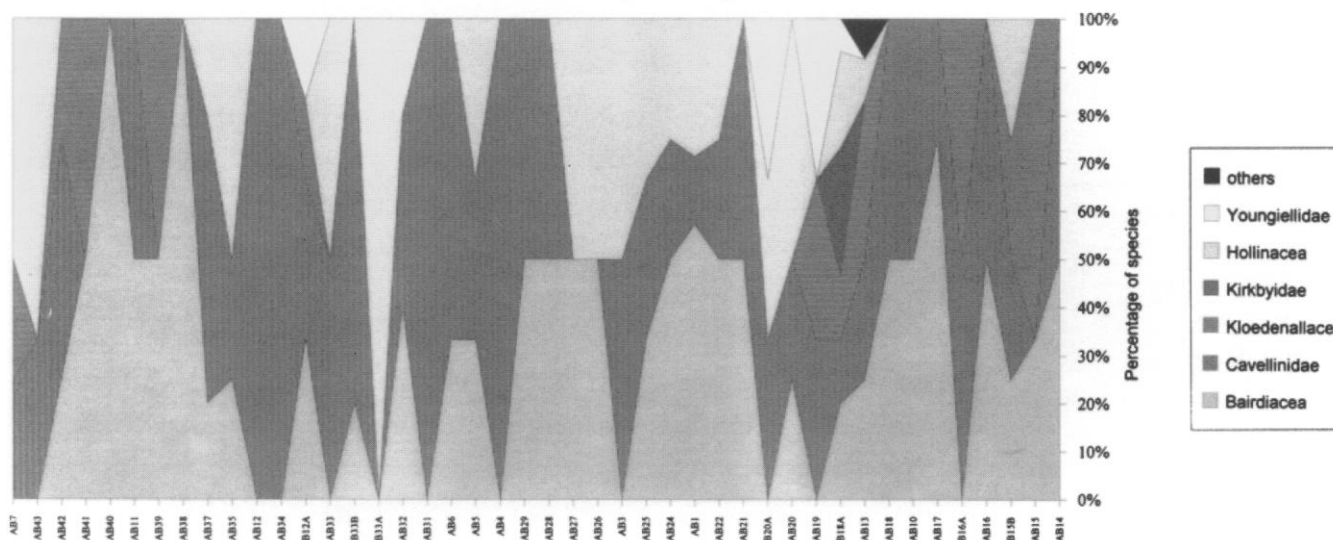
***Carinaknightina braccinii* Crasquin-Soleau n. sp.**

Plate 1, figures 4-7

**Etymology:** Dedicated to Dr. Eric Braccini, Elf-Aquitaine, Pau, France.

**Holotype:** One complete carapace, figured plate 1, figure 4, collection number MGL74654.

## Evolution of ostracode assemblage



TEXT-FIGURE 4  
Variation of the ostracode assemblage through the Khuff Formation section.

**Paratype:** One complete carapace, figured plate 1, figure 5, collection number MGL74655.

**Type level:** Sample AB18A, top of the lower unit of Khuff Formation, central Oman, Middle Permian (lower Wordian).

**Diagnosis:** Species of *Carinaknightina* with subrectangular carapace, with a ridge beginning in ACA finishing in PCA, a continuous ridge from dorsal margin, beginning behind ACA, going below the pit to posterior part of dorsal margin and following dorsal margin, and the presence of a transverse ridge connecting the anterior and posterior parts of the last one, passing up to the pit.

**Description:** Subrectangular carapace; dorsal margin straight; ACA and PCA well-expressed, ACA= 135°, PCA= 120°; anterior margin rounded with maximum convexity located at 56% of height; ventral margin straight; posterior margin with a large radius of curvature, maximum convexity located at mid-height; presence of 4 ridges: the first ridge following ventral margin and join cardinal angles; the second one begins in ACA, follows the free margins and finishes in PCA; the third one is close, begins behind ACA following the free margins up to the last one, joins dorsal margin behind PCA and follows dorsal margin; the fourth one is transverse, incurved, joins the anterior and posterior parts of the last one, passing up over the pit; presence of kirkbyan pit in central part of the carapace; presence of reticulation, almost in the pit area.

**Remarks:** *Carinaknightina braccinii* Crasquin-Soleau n. sp. is close to *Carinaknightina tricarinata* Kozur 1985 from the Abadehian of Hungary; however, it differs in the pattern of ridges.

**Size:** L= 0.62 to 1.15mm; H= 0.42 to 0.63mm.

**Distribution:** Khuff Formation (samples AB18A/JB43, see table 2), Huqf area, central Oman, Middle Permian (lower Wordian).

Superfamily HOLLINACEA Swartz 1936  
Family HOLLINELLIDAE Bless and Jordan 1971  
Genus *Jordanites* Bless 1965

***Jordanites lordi* Crasquin-Soleau n. sp.**  
Plate 1, figures 15-19

**Etymology:** Dedicated to Pr. Alan Lord, University College London, Great Britain.

**Holotype:** One complete carapace, figured pl. 1, fig. 15, collection number MGL74664.

**Paratype:** One complete carapace, figured pl.1, fig.17, collection number MGL74666.

**Type level:** Sample AB43, uppermost part of unit 5 of Khuff Formation, central Oman, Middle Permian (lower Wordian).

**Diagnosis:** Species of *Jordanites* with carapace with well-expressed L3 and punctuation.

**Description:** Dorsal margin straight and short; ACA= 133°; PCA= 130°; L1 observed only on one specimen, going through the ventral part; S1 very tumid when present; L2 small, well-expressed only in its posterior part; S2 narrow; L3 well developed, extended above hinge line, ventral part blending with the ventral part of the carapace; maximum convexity of anterior margin located slightly below mid-height; maximum convexity of posterior margin located at 35% of height; maximum height located at 33 to 39% of length; posterior part of the carapace (behind L3) flattened laterally; presence of punctuation; smooth ventral velum.

TABLE 1

Correlation of the Permian scales (Crasquin-Soleau 1998)

1- International scale: Stratigraphic Permian Subcommittee of International Union Geological Sciences proposed during Beijing International Meeting (1996), in Waterhouse (1997)

2, 4 and 5 after Ross and Ross (1994)

3- after Baud et al. (1993a) and Davidov (1996); absolute ages in Baud et al. (1993a)

4- absolute ages from Mennig (1995)

No vertical scale.

Proposed world scale ①				North America ②	Western Tethys ③	Ural and Russian Platform ④	South China ⑤			
Triassic				Induan	Induan	Induan	Induan			
PERMIAN	UPPER	Lopingian	Changhsingian	Ochoan	Dorashamian	Tatarian	Changhsingian	251+/-2		
			Wuchiapingian		255 Dzhulfian		Wuchiapingian			
	MIDDLE	Guadalupian	Capitanian	Capitanian	Guadalupian		Midian	Maokouan	259 264 269 273	
			Wordian	Wordian			Murgabian			— ? — 267 Kazanian
			Roadian	Roadian			Kubergandian			? — 272 Ufimian
										? — 274
	LOWER	Cisuralian	Kungurian / Leonardian	Cathedralian	Leonardian	Bolorian	Kungurian	Chihhsian	275 277 283 290	
			Artinskian	Hessian		Artinskian	Artinskian			
			Sakmarian	Lexonian	Wolfcampian	Sakmarian	Sakmarian	Longhnanian or Changmoan		
			Asselian	Nealian		Asselian	Asselian	Mapingian		

295+/-5

**Remarks:** This genus described by Bless (1967) has been recorded from Westphalian C-D and Stephanian? The occurrence of the genus should now be extended to Middle Permian (lower Wordian).

*Jordanites lordi* Crasquin-Soleau n. sp. could be compared to *Jordanites cristinae* (Bless 1965) from Westphalian C-D of Spain, however, the posterior margin of *Jordanites lordi* Crasquin-Soleau n. sp. has a larger radius of curvature.

**Size:** L= 1.22 to 1.43mm; H= 0.67 to 0.82mm.

**Distribution:** Khuff Formation (samples AB18A to AB43, see table 2), Huqf area, central Oman, Middle Permian (lower Wordian).

Genus *Hollinella* Coryell 1928 emend. Kellett 1929  
Subgenus *Hollinella* (*Hollinella*) Coryell 1928

***Hollinella* (*Hollinella*) *benzartiae* Crasquin-Soleau n. sp.**  
Plate 2, figure 1-4

?1987 *Hollinella* (*Hollinella*) sp., aff. *H. (H.) bassleri* (Knight 1928)  
PRIBYL and PEK, pp. 67-68, pl. 1, figs. 4-5, pl. 2, fig. 1

**Etymology:** Dedicated to Dr. Rakia Benzarti-Said, SEREPT, Tunis, Tunisie.

**Holotype:** One complete carapace, figured pl. 2, fig. 1, collection number MGL74669.

**Paratype:** One complete carapace, figured pl. 2, fig. 2, collection number MGL74670.

**Type level:** Sample AB24, lower part of upper unit of Khuff Formation, central Oman, Middle Permian (lower Wordian).

**Diagnosis:** A species of *Hollinella* (*Hollinella*) with L2 and L3 round, bulbous, isolated from the rest of the carapace and located close together in the dorsal half of valve; surface smooth.

**Description:** Dorsal margin straight; ACA=PCA= 130 to 145°; anterior margin with maximum convexity located at mid-height (excluding fringe); posterior margin with maximum convexity located at 30% of height (excluding fringe); L1 very attenuated, not always visible; S1 undistinct; L2 round, small, bulbous, isolated; S2 open ventrally; L3 large, round, bulbous, isolated; large striated velum beginning at ACA and finishing in ventral part of posterior margin; maximum height (excluding fringe) located at 40% of length; surface smooth.

TABLE 2

Middle Permian ostracode occurrence in the Khuff Formation (no vertical scale).

\* : observed presence of species

— : deduced presence of species

Species of Khuff Formation - Upper Permian		1 <i>Fabaticypris parva</i> WANG 1978	2 <i>Cavellina?</i> <i>hugfensis</i> n.sp.	3 <i>Sargentina minuta</i> WANG 1978	4 <i>Sargentina woutersi</i> n.sp.	5 <i>Bairdia cf. acrisa</i> STEPANAITYS 1975	6 <i>Hollinella</i> (H.) <i>benzartiae</i> n.sp.	7 <i>Acratia cf. subularis</i> GUSSEVA 1972	8 <i>Bairdia omanensis</i> n.sp.	9 <i>Cavellina gerryi</i> n.sp.	10 <i>Acratina diffusa</i> SCHNEIDER 1959	11 <i>Perprimitia brevirostris</i> SCHNEIDER 1956	12 <i>Perprimitia</i> sp.	13 <i>Roundyella cf. bellatula</i> BRADFIELD 1935	14 <i>Cavellina boomeri</i> n.sp.	15 <i>Hollinella</i> (H.) <i>martensi</i> n.sp.	16 <i>Knightsina unnoda</i> (WANG 1978)	17 <i>Sulcella superpermiana</i> KOZUR 1985	18 <i>Kindella</i> sp 1	19 <i>Knightsina cf. fildari</i> PAYNE 1937 sensu C-S. & O. 1994	20 <i>Placidea cf. petchorensis</i> SCHNEIDER 1966	21 <i>Langdaia hornet</i> n.sp.	22 <i>Carniaknightsina braccinii</i> n.sp.	23 <i>Acratia</i> n.sp.3	24 <i>Sargentina transitia</i> (KOZUR 1985)	25 <i>Jordanites lordi</i> n.sp.	26 <i>Hollinella</i> (H.) <i>herrickana</i> (GIRTY 1909)	27 <i>Moorites cf. minutus</i> (WARTHIN 1930)	28 <i>Moorites cf. suboblonga</i> (WANG 1978)	29 <i>Acratia</i> n.sp.2	30 <i>Sulcella arabica</i> n.sp.	31 <i>Bairdia</i> sp. 1	32 <i>Cavellina</i> n.sp.4	33 <i>Sulcella sulcata</i> CORYELL & SAMPLE 1932	34 <i>Birdsallia?</i> spp.	35 <i>Healdianella?</i> n.sp.	
AB7		*	*																																		
AB43		*	*																																		
AB42/8		*	*	*																																	
AB41		*		*																																	
AB40		*		*					*																												
AB11		*		*					*																												*
AB39		*		*					*																												
AB38		*		*					*																												
AB37		*		*					*	*					*																			*			
AB35		*		*					*						*																						
AB12		*	*	*					*						*																						
AB34		*	*	*					*						*																						
AB12A/33C		*	*	*	*				*						*																		*			*	
AB33		*	*	*					*	*					*																						
AB33B		*	*	*					*	*					*																			*		*	
AB33A		*	*	*					*	*					*																						
AB32		*	*	*					*	*					*																		*				
AB31		*	*	*					*	*					*																						
AB6/30		*	*	*					*	*					*																						
AB5		*	*	*					*	*					*																						
AB4		*	*	*					*	*					*																						
AB29		*	*	*					*	*					*																						
AB28		*	*	*					*	*					*																						
AB27		*	*	*					*	*					*													*	*	*							
AB26		*	*	*					*	*					*													*	*	*							
AB3 - B		*	*	*					*	*					*													*	*	*							
AB25		*	*	*					*	*					*													*	*	*							
AB24/JB47		*	*	*		*			*	*					*													*	*	*							
AB1/23		*	*	*		*	*	*	*	*					*																	*					
AB22/JB46		*	*	*		*	*	*	*	*					*													*	*	*							
AB21/JB45		*	*	*		*	*	*	*	*					*													*	*	*							
AB20A/JB44		*	*	*		*	*	*	*	*					*													*	*	*							
AB20		*	*	*		*	*	*	*	*					*													*	*	*							
AB19		*	*	*		*	*	*	*	*					*												*	*	*		*						
AB18A/JB43		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
AB13		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
AB18		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
AB10		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
AB17		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
AB16A/JB42		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
AB16		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
AB15B/JB41		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
AB15/JB39		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
AB14/JB38		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*



**Remarks:** *Hollinella (Hollinella) benhartiae* Crasquin-Soleau n. sp. could be compared to *Hollinella (Hollinella) cristinae* Bless 1965 from lower Westphalian A of The Netherlands, which has the same kind of isolated L2 and L3, but differs by other characters. ?*Hollinella (Hollinella)* sp., aff. *H. (H.) bassleri* (Knight 1928) *sensu* Pribyl and Pek 1987 from the Lower Permian of Bolivia is questionably put in synonymy with our new species. Indeed as the authors said, their material is not well preserved and the surface seems to be granulose.

**Size:** L (without fringe)= 0.92 to 1.02µm; H (without fringe)= 0.50 to 0.63µm.

**Distribution:** Khuff Formation (samples JB41 to AB24, see table 2), Huqf area, central Oman, Capacabana Formation?, Titicaca Group?, Bolivia?, ?Lower Permian - Middle Permian (lower Wordian).

***Hollinella (Hollinella) martensi* Crasquin-Soleau n. sp.**  
Plate 2, figures 6-10

**Etymology:** Dedicated to Dr. Koen Martens, Royal Belgium Institute of Natural Sciences, Brussels, Belgium.

**Holotype:** One complete carapace, figured plate 2, figure 7, collection number MGL74675.

**Paratype:** One complete carapace, figured plate 2, figure 8, collection number MGL74676.

**Type level:** Sample AB32, middle part of upper unit of Khuff Formation, central Oman, Middle Permian (lower Wordian).

**Diagnosis:** Species of *Hollinella (Hollinella)* with L2 round and isolated, L3 bulbous with ventral part in connection with ventral part of the carapace; frill formed of a row of small tubercles; presence of 3 or 4 tubercles on the upper part of L3.

**Description:** Carapace with H/L= 0.52 to 0.57; dorsal margin straight; anterior margin with great radius of curvature, maximum convexity located at mid-height; ventral margin regularly convex; maximum height located slightly anterior of mid-length; posterior margin with small radius of curvature, maximum convexity located at 35% of height; right valve overlaps left valve a little on free margins; L1 and S1 observable only in very few cases; L2 round, small, bulbous; S2 open and deep; L3 round but connecting ventrally with the surface of the carapace, 3 or 4 tubercles present on the upper part; frill composed of a row of small tubercles, regularly spaced; in some cases a second row of tubercles is present parallel to the first one; surface smooth.

**Remarks:** *Hollinella (Hollinella) martensi* Crasquin-Soleau n. sp. could be compared to *Hollinella (Hollinella) menardensis* Harlton 1929 from the Upper Carboniferous - Upper Permian of USA, Egypt (Adindani et al. 1977) and Tunisia (Lethiers et al. 1989) but differs from it by the diagnosis characters.

**Size:** L= 0.75 to 1.27µm; H= 0.47 to 0.67µm.

**Distribution:** Khuff Formation (samples AB13 to AB7, see table 2), Huqf area, central Oman, Middle Permian (lower Wordian).

Order PODOCOPIDA Müller 1894  
Suborder PODOCOPINA Sars 1866  
Superfamily BAIRDIACEA Sars 1888  
Family BAIRDIIDAE Sars 1888  
Genus *Bairdia* McCoy 1844

***Bairdia omanensis* Crasquin-Soleau n. sp.**  
Plate 5, figure 10-13

**Etymology:** From Oman, country where the material was found.

**Holotype:** One complete carapace, figured pl. 5, fig. 10, collection number MGL74726.

**Paratype:** One complete carapace, figured pl. 5, fig. 12, collection number MGL74728.

**Type level:** Sample AB23, lower part of the upper unit of Khuff Formation, central Oman, Middle Permian (lower Wordian).

**Diagnosis:** Species of *Bairdia* with very elongate carapace, anterior and posterior margins with small radius of curvature.

**Description:** Very elongate carapace (H/L=0.52); dorsal margin convex; anterior margin with small radius of curvature, maximum convexity located at mid-height; ventral margin convex at left valve, concave on right one; posterior margin very elongate with very small radius of curvature, maximum convexity located at 70% of height; maximum height located at mid-length; dorsal view biconvex; surface smooth.

**Size:** L= 0.75 to 1.25µm; H= 0.36 to 0.67µm.

**Distribution:** Khuff Formation (samples AB17 to AB40, see table 2), Huqf area, central Oman, Middle Permian (lower Wordian).

Order PLATYCOPIDA Sars 1866  
Suborder PLATYCOPINA Sars 1866  
Family CAVELLINIDAE Egorov 1950  
Genus *Cavellina* Coryell 1928

***Cavellina huqfensis* Crasquin-Soleau n. sp.**  
Plate 3, figure 13-17

**Etymology:** From Huqf area, central Oman.

**Holotype:** One complete carapace, figured pl.3, fig.14, collection number MGL74698.

**Paratype:** One complete carapace, figured pl.3, fig.15, collection number MGL74699.

**Type level:** Sample AB18, upper part of the lower unit of Khuff Formation, central Oman, Middle Permian (lower Wordian).

**Diagnosis:** Species of *Cavellina* with short carapace (H/L= 0.85), outline rounded, flattened in anterior and dorso-median parts.

**Description:** Carapace short (H/L= 0.85) with rounded outline; right valve: dorsal, anterior and posterior margins regularly convex, ventral margin straight, small shoulder parallel to posterior margin, maximum curvature of anterior margin at mid-height, of posterior margin at 65% of height; left valve: anterior part of dorsal margin straight, posterior part straight to gently convex, anterior and posterior margins convex, ventral margin straight

TABLE 3

Relationships between the Khuff Formation ostracode fauna and other known Permian localities.

1. Kozur 1985; 2. Wang 1978; 3. Shi 1987; 4. Gerry et al. 1987; 5. Lethiers et al. 1989; 6. Crasquin-Soleau and Baud 1998; 7. Crasquin-Soleau and Orchard 1994, Warthin 1930 in Melnyk and Maddocks 1988, Bradfield 1935, Coryell and Sample 1932, in Lethiers and Crasquin-Soleau 1995; 8. Gusseva 1972 in Kotchetkova and Gusseva 1972, Schneider 1958 in Kotchetkova and Gusseva 1972, Schneider 1956 in Kotchetkova 1959, Schneider 1966 and in Lethiers et al. 1989.

\*: presence of species

cf.: related species

Palaeobiogeographic relationships of Upper Permian Ostracods of Khuff Formation	endemic	Hungaria 1	South China 2	North China 3	Israel 4	Tunisia 5	Greece 6	USA/Canada 7	Russian Platform 8
<i>Acratia</i> cf. <i>subularis</i> GUSSEVA 1972									<b>cf.</b>
<i>Acratia</i> n.sp.2	*								
<i>Acratia</i> n.sp.3	*								
<i>Acratina</i> <i>diffusa</i> SCHNEIDER 1956									*
<i>Bairdia</i> cf. <i>acrisa</i> STEPANAITYS 1975									<b>cf.</b>
<i>Bairdia</i> <i>omanensis</i> n.sp.	*								
<i>Bairdia</i> sp.1	*								
<i>Birdsallia</i> ? spp.	*								
<i>Carinaknightina</i> <i>braccinii</i> n.sp.	*								
<i>Cavellina</i> <i>boomeri</i> n.sp.	*								
<i>Cavellina</i> <i>gerryi</i> n.sp.					*				
<i>Cavellina</i> <i>huqfensis</i> n.sp.	*								
<i>Cavellina</i> n.sp.4	*								
<i>Fabalicypis</i> <i>parva</i> WANG 1978			*						
<i>Healdianella</i> ? n.sp.	*								
<i>Hollinella</i> (H.) <i>benzartiae</i> n.sp.	*								
<i>Hollinella</i> (H.) <i>herrickana</i> (GIRTY 1909)						*		*	*
<i>Hollinella</i> <i>martensi</i> n.sp.	*								
<i>Jordanites</i> <i>lordi</i> n.sp.	*								
<i>Kindella</i> sp.1	*								
<i>Knightina</i> cf. <i>fildari</i> PAYNE 1937 sensu CS. & O. 1994								*	
<i>Knightina</i> <i>unnoda</i> (WANG 1978)			*				<b>cf.</b>		
<i>Langaia</i> <i>hornei</i> n.sp.	*								
<i>Moorites</i> cf. <i>suboblonga</i> (WANG 1978)			<b>cf.</b>						
<i>Moorites</i> cf. <i>minutus</i> (WARTHIN 1930)								<b>cf.</b>	
<i>Perprimitia</i> <i>brevirostris</i> SCHNEIDER 1958									*
<i>Perprimitia</i> sp.	*								
<i>Placidea</i> cf. <i>petschorensis</i> SCHNEIDER 1966									<b>cf.</b>
<i>Roundyella</i> cf. <i>bellatula</i> BRADFIELD 1935				<b>cf.</b>				<b>cf.</b>	
<i>Sargentina</i> <i>minuta</i> WANG 1978			*						
<i>Sargentina</i> <i>transita</i> (KOZUR 1985)		*							
<i>Sargentina</i> <i>woutersi</i> n.sp.	*								
<i>Sulcella</i> <i>arabica</i> n.sp.	*								
<i>Sulcella</i> <i>sulcata</i> CORYELL & SAMPLE 1932		*				*		*	*
<i>Sulcella</i> <i>superpermiana</i> KOZUR 1985		*			*		*		
TOTAL	18	3	3+1	1	2	2	1+1	3+1	4+3
PI= C/2E1		0.08	<b>0.08/0.11</b>	0.01	0.05	0.05	0.02	<b>0.08/0.11</b>	<b>0.11/0.19</b>

to gently concave; maximum height located slightly posterior of mid-length; valves flattened in posterior part behind shoulder, in dorso-median part; dorsal view biconvex, hinge line straight; surface smooth.

Size: L= 0.59 to 0.67µm; H= 0.47 to 0.59µm.

Distribution: Khuff Formation (samples AB14 to AB7, see table 2), Huqf area, central Oman, Middle Permian (lower Wordian).

*Cavellina gerryi* Crasquin-Soleau n. sp.

Plate 4, figures 9-11

*Cavellina* sp. GERRY et al. 1987 p. 211, pl. 1, fig. 1-2.

*Etymology*: Dedicated to Dr. Ephraim Gerry, Israel Institute of Petroleum and Energy, Tel Aviv, Israel.

*Holotype*: One complete carapace, figured pl. 4, fig. 9, collection number MGL74710.

*Paratype*: One complete carapace, figured pl. 4, fig. 11, collection number MGL74712.

*Type level*: Sample AB18, upper part of the lower unit of Khuff Formation, central Oman, Middle Permian (lower Wordian).

**Diagnosis:** Species of *Cavellina* with small shoulder parallel to posterior margin and flattening in antero-median, postero-median and dorso-median parts of valves.

**Description:** Carapace with H/L = 0.65; right valve: dorsal, anterior and posterior margins convex, ventral margin gently concave to gently convex; left valve: dorsal, anterior and posterior margins convex, ventral margin straight to concave; on both valves: small fine shoulder in posterior part, parallel to posterior margin, flattening in antero-median, postero-median and dorso-median parts; right valve overlaps left one all around the carapace with most important overlap in dorsal and ventral parts; maximum height located at mid-length; surface smooth.

**Remarks:** *Cavellina gerryi* Crasquin-Soleau n. sp. could be compared to *Sulcella? posteracuminata* Wang 1978 from Late Permian - Lower Triassic of southern part of South China. This latter species seems (the description is in Chinese and the illustration is poor) to be very close but has a truncated postero-ventral margin. *Cavellina visnyoensis* Kozur 1985 from the lower Abadehian of Hungary is also close to our species but has a greater height and lacks the fine shoulder.

**Size:** L = 0.74 to 0.92mm; H = 0.46 to 0.61mm.

**Distribution:** Khuff Formation (samples AB18 to AB37, see table 2), Huqf area, central Oman, Middle Permian (lower Wordian).

***Cavellina boomeri* Crasquin-Soleau n. sp.**  
Plate 4, figures 1-4

**Etymology:** Dedicated to Dr. Ian Boomer, University of East Anglia, Norwich, Great Britain.

**Holotype:** One complete carapace, figured pl. 4, fig. 1, collection number MGL74702.

**Paratype:** One complete carapace, figured pl. 4, fig. 2, collection number MGL74703.

**Type level:** Sample AB12, upper part of the upper unit of Khuff Formation, central Oman, Middle Permian (lower Wordian).

**Diagnosis:** Species of *Cavellina* with elongate carapace with sub-triangular outline, long posterior part of dorsal margin, posterior margin with radius of curvature more important than anterior margin.

**Description:** Carapace with sub-triangular outline; dorsal margin with long straight anterior part, anterior part straight to gently convex; posterior margin rounded with maximum convexity located slightly ventral of mid-height; ventral margin convex on right valve, gently concave on left one; anterior margin rounded with maximum convexity located at mid-height; right valve overlaps left one in dorsal, anterior and ventral parts; maximum height located slightly posterior of mid-height; carapace smooth.

**Size:** L = 0.68 to 0.76mm; H = 0.41 to 0.46mm.

**Distribution:** Khuff Formation (samples AB18A/JB43 to AB37, see table 2), Huqf area, central Oman, Middle Permian (lower Wordian).

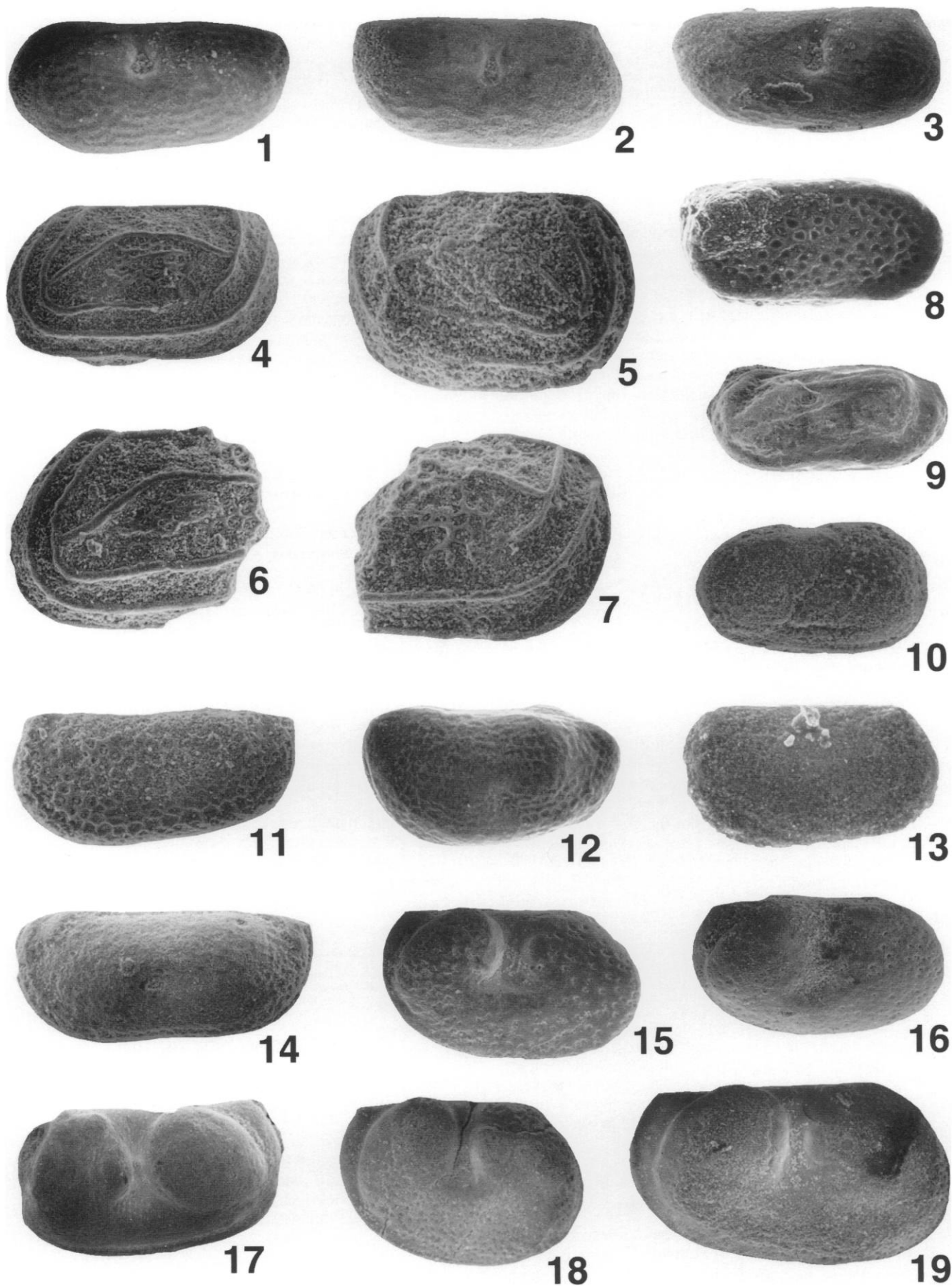
Genus *Sulcella* Coryell and Sample 1932

***Sulcella arabica* Crasquin-Soleau n. sp.**  
Plate 4, figures 12-14

**Etymology:** From Arabian Platform.

## PLATE 1

- 1-3 *Langdaia hornei* Crasquin-Soleau n.sp. 1, Holotype, left lateral view, X55, MGL74651, sample JB43. 2, paratype, right lateral view, X55, MGL74652, sample JB43. 3, right lateral view, X55, MGL74653, sample JB43.
- 4-7 *Carinaknightina braccinii* Crasquin-Soleau n.sp. 4, Holotype, left lateral view, X45, MGL74654, sample A18A. 5, Paratype, right lateral view, X80, MGL74655, sample JB43. 6, Fragment of left valve, lateral view, X60, MGL74656, sample JB43. 7, Fragment of left valve, lateral view, X65, MGL74657, sample JB43.
- 8 *Moorites* cf. *suboblonga* (Wang, 1978), left lateral view, X55, MGL74733, sample A20A.
- 9 *Moorites* cf. *minutus* (Warthin, 1930), right lateral view, X30, MGL74658, sample A19.
- 10 *Roundyella* cf. *bellatula* Bradfield, 1935, left lateral view, X90, MGL74659, sample A13.
- 11 *Knightina* cf. *fidari* Payne 1937 *sensu* Crasquin-Soleau and Orchard 1994, left lateral view, X65, MGL74660, sample JB43.
- 12 *Kindella* sp.1, left lateral view, X65, MGL74661, sample A18A.
- 13 *Placidea* cf. *petschorensis* Schneider 1966, left lateral view, X100, MGL74662, sample JB43.
- 14 *Knightina unnoda* (Wang 1978), left lateral view, X40, MGL74663, sample JB43.
- 15-19 *Jordanites lordi* Crasquin-Soleau n. sp. 15, holotype, right lateral view, X35, MGL74664, sample A43. 16, right lateral view, X35, MGL74665, sample A18A. 17, paratype, left lateral view, X30, MGL74666, sample A35. 18, right lateral view, X35, MGL74667, sample A27. 19, right lateral view, X40, MGL74668, sample A27.



**Holotype:** One complete carapace, figured plate 4, figure 12, collection number MGL74713.

**Paratype:** One complete carapace, figured plate 4, figure 14, collection number MGL74715.

**Type level:** Sample AB33B, middle part of the upper unit of Khuff Formation, central Oman, Middle Permian (lower Wordian).

**Diagnosis:** Species of *Sulcella* with broad anterior margin and narrow posterior one; small sulcus in medio-central part of the carapace.

**Description:** Dorsal margin regularly arched; anterior margin with great radius of curvature, maximum convexity located at mid-height; ventral margin straight on right valve, concave on left one; posterior margin with small radius of curvature, maximum convexity located at 62% of height; maximum height located at 42 to 47% of length; presence of a shallow sulcus located in median part of the carapace; surface smooth.

**Size:** L= 0.64 to 0.70µm; H= 0.38 to 0.42µm.

**Distribution:** Khuff Formation (samples AB5 to AB33B, see table 2), Huqf area, central Oman, Middle Permian (lower Wordian).

## PALEOECOLOGICAL SETTING

The marine Permian ostracodes are relatively well known in North America until the Leonardian (see the compilation in Melnyk and Maddocks 1988 a and b). On the Russian and on the Chinese platforms some data are available but are difficult to take into consideration with the problem of language. Studies of material from Europe, the Middle East and North Africa are rare. In North Africa, two papers have been published on the Upper Permian of South Tunisia (Lethiers et al. 1989; Said-Benzarti and Crasquin-Soleau 1998). In the Middle East, Gerry et al. (1987) reported 28 species from the Upper Permian. In Europe, the main results are due to Kozur (1985) in Hungary and a study on the Upper Permian of Greece (Hydra Island) has been completed (Crasquin-Soleau and Baud 1998).

Some paleoecological interpretations can be proposed for the Khuff Formation section. The ostracode genera encountered are known to be benthic, shallow-marine forms.

The paleoecological requirements of families or superfamilies are now relatively well known from the studies on the relationship between facies and species of the Lower Permian of Texas (Melnyk and Maddocks 1988a) and Kansas (Peterson and Kaesler 1980; Costanzo and Kaesler 1987)

We can summarize, after the above mentioned authors, the main characteristics of families and superfamilies found here as follows. The Bairdiacea are present in shallow to deep, open carbonate environments with normal salinity. The Cavellinidae were adapted to very shallow to shallow euryhaline environments. The Kloedenellacea were inhabitant of very shallow, euryhaline environments. The Kirkbyidae spread out in subtidal, normal-marine environments. The large species of Hollinacea with developed adventral structures can characterize environments such as interdistributary bay, prodelta and interdeltaic embayments, and lagoons. The Youngiellidae were inhabitants of shallow, normal-marine environments.

Text-figure 3 shows the distribution of the species in percentage of families or superfamilies in the Khuff section:

- the Bardiacea are not very abundant for the time interval considered (26% of species)
- the Cavellinidae (20% of species), the Kloedenellacea (17%) and Hollinacea (14%) dominate the ostracode assemblages.
- the sublittoral Kirkbyidae represent 17% of species.

Almost all the specimens present are closed carapaces. This indicates a limited transportation, a soft substratum and a relatively high rate of sedimentation (Oertli 1971). The species are present generally only as adults and the last larval stage. This indicates a high energy biocoenosis or thanatocoenosis (Whatley 1983, 1988; Brouwers 1988).

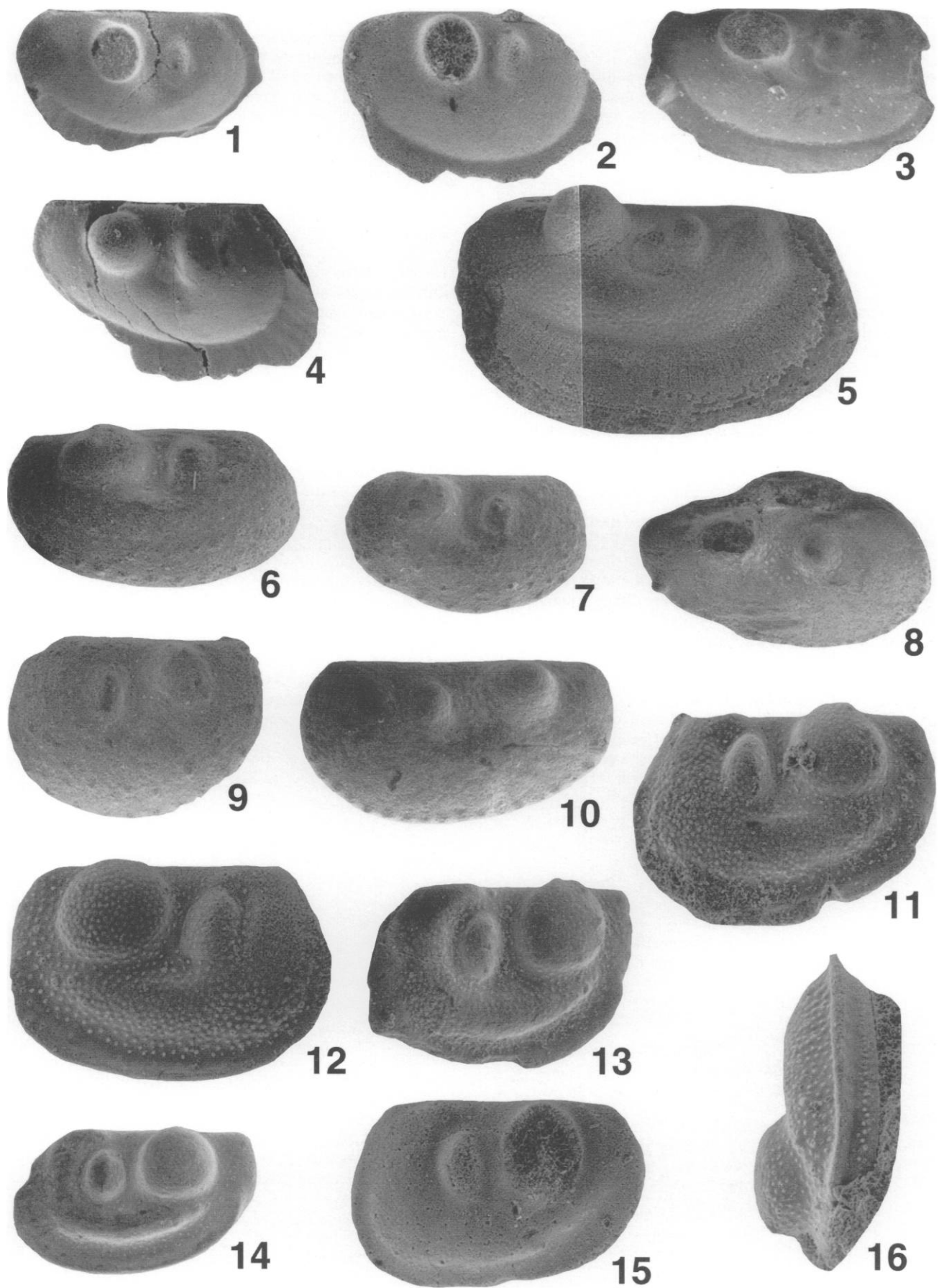
It is also important to note the relatively low diversity of the assemblage (35 species) and that some species are represented by a very high number of specimens, e.g., *Hollinella* (*H.*) *herrickana*. It is now well known that diversity is lower in

## PLATE 2

- 1-4 *Hollinella* (*H.*) *benzartiae* Crasquin-Soleau n. sp. 1, holotype, right lateral view, X40, MGL74669, sample A24. 2, paratype, right lateral view, X40, MGL74670, sample A24. 3, right lateral view, X40, MGL74671, sample JB41. 4, right lateral view, X40, MGL74672, sample A24.
- 5 *Hollinella* (*H.*) *herrickana* (Girty 1909)? right lateral view, X30, MGL74673, sample A22.
- 6-10 *Hollinella* (*H.*) *martensi* Crasquin-Soleau n. sp. 6, right lateral view, X50, MGL74674, sample A32. 7, holotype, right lateral view, X50, MGL74675, sample

A32. 8, paratype, right sub-lateral view, X30, MGL74676, sample A32. 9, left lateral view, X55, MGL74677, sample A32. 10, left lateral view, X40, MGL74678, sample A32.

- 11-16 *Hollinella* (*H.*) *herrickana* (Girty 1909) 11, left lateral view, X40, MGL74679, sample A23. 12, right lateral view, X40, MGL74680, sample A22. 13, left lateral view, X35, MGL74681, sample A24. 14, left lateral view, X30, MGL74682, sample A20. 15, left lateral view, X40, MGL74683, sample A5. 16, ventral view, X40, MGL74684, sample A22.



brackish, marginal-marine environments than in open-sea environments (see Whatley 1983).

From all these observations, we can deduce that the Middle Permian paleoenvironment of the Khuff Formation was very shallow marine (between 1 and 10m deep), sublittoral, under the action of waves, with important variations of salinity. Species lived on a soft substratum under a high rate of sedimentation.

If we observe the variations of composition along the section (text-fig.4), we can see that the variations in ostracode assemblage composition are rapid and frequent. This could be explained by the littoral position of the site. In such a shallow, high-energy location, the modifications of life conditions (salinity, oxygenation, amount of sediment in suspension, temperature, etc.) could be frequent and reversible. As a first approximation, it does not seem that the storm levels have a direct influence on the ostracode assemblage, but new data on other fossil groups (Angiolini pers. com.) show a much deeper environment (near wave base) and could induce mass transport of the ostracode fauna. This part of the analysis is now already in progress with the microfacies analysis.

#### PALEOBIOGEOGRAPHIC RELATIONSHIPS

For the paleobiogeographic analysis, we used the provincialism index (PI) of Johnson (1971) ( $PI = C/2E_1$ , where C is the number on common species between two areas and  $E_1$  the number of endemic species of the area where they are the less). This index permits comparison of areas that have very different numbers of species. Using this method, Lethiers and Crasquin-Soleau (1995) proposed a global distribution pattern of the Upper Carboniferous and Permian ostracodes.

The Permian ostracodes are relatively well known in USA (Lower Permian) and in Russia (see exhaustive bibliography by Lethiers and Crasquin-Soleau 1995). The available data on Middle - Upper Permian of the Tethys domain *l.s.* come from Hungary (Zanályi 1974; Kozur 1985), Tunisia (Lethiers et al.

1989; Said-Benzarti and Crasquin-Soleau 1998), Greece (Crasquin-Soleau and Baud 1998), Israel (Gerry et al. 1987), South China - northern part (Wang 1978) and southern part (Hou 1954; Chen 1958, Chen and Shi 1982, Chen and Bao 1986, Shi and Chen 1987; Zhang and Liang 1987, 1991; Yi 1990), North China (Shi 1987; Shi and Li 1988). A study was realized in Japan (Ishizaki 1964).

Table 3 gives the relationships between Khuff Formation ostracode fauna and those from other known Permian localities. The bottom lines present the numbers of common and close species and the provincialism index.

The table shows that the PI is the highest with Russian Platform (0.11 and 0.19 with close species), followed at the same level by North America and South China (0.08 and 0.11) and then, in decreasing order, Hungary (0.08), Israel and Tunisia (0.05), Greece (0.01 and 0.02) and North China (only one species close).

These paleobiogeographical relationships could be explained by the importance of the surface paleocurrents from east to west (North Equatorial Current and South Equatorial Current) in the Paleotethys realm (Lethiers and Crasquin-Soleau 1995), which carried ostracodes on biological rafts and spread and seeded infralittoral areas.

#### CONCLUSION

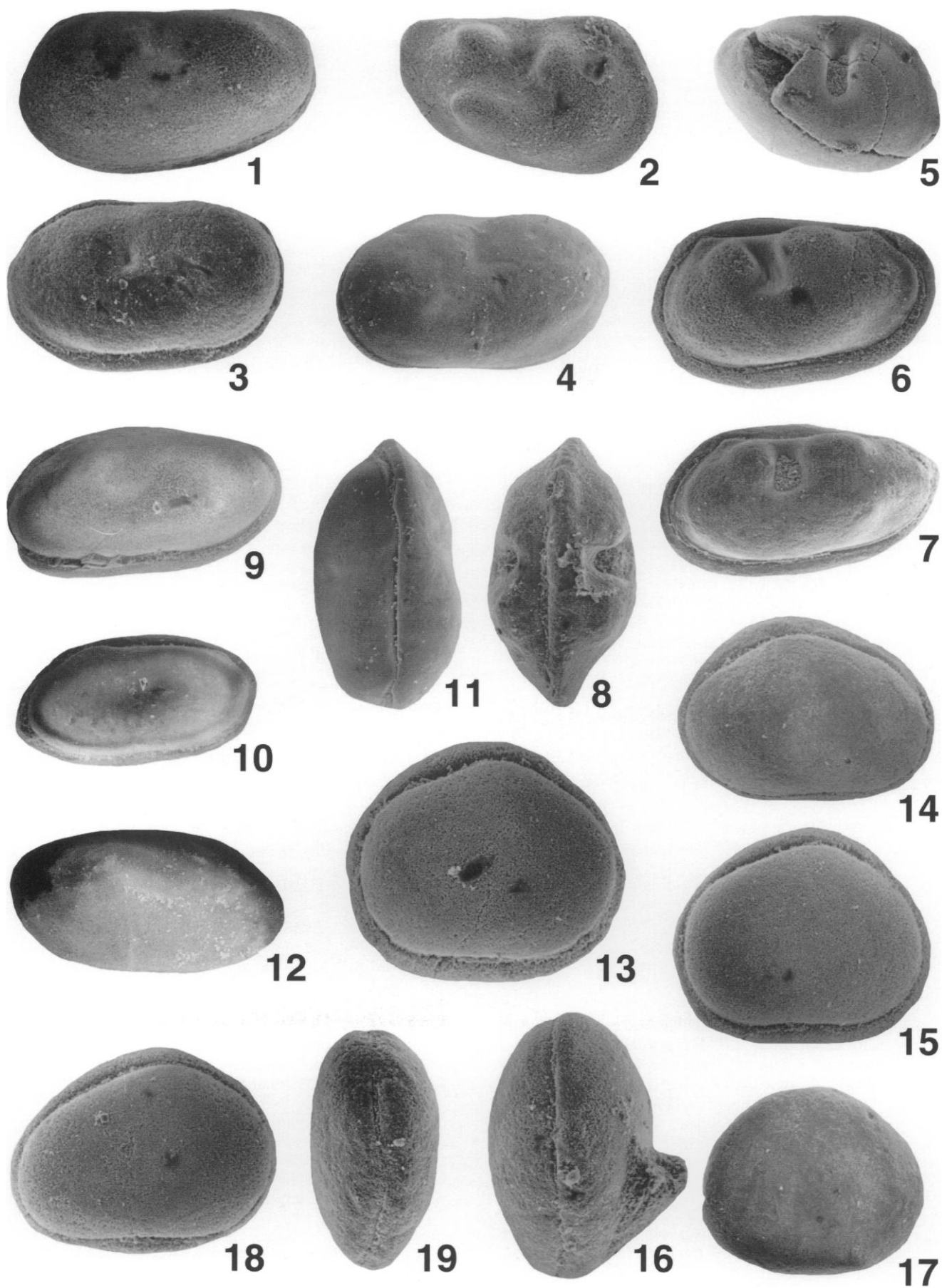
This study is the first on Permian ostracodes of the Arabian Plate. Thirty-five species are recognized, and eleven are new. The age of the fauna is lower Wordian. The paleoecological analysis shows that the Khuff Formation was deposited in a very shallow marine, sublittoral environment under the action of waves, and the bottom was soft. The analysis of the relationship between the storm levels and the composition of the ostracode assemblages is in progress, although the strong variations in composition do not seem to be linked with this phenomenon.

Paleobiogeographic relationships are strong with the Russian Platform, North America, and South China. This could be ex-

#### PLATE 3

- 1 *Perprimitia brevirostris* Schneider 1958, left lateral view, x70, MGL74685, sample A13.
- 2 *Perprimitia* sp., right lateral view, x55, MGL74686, sample A13.
- 3-4 *Sargentina minuta* Wang 1978. 3, left lateral view, x60, MGL74687, sample JB41. 4, right lateral view, x50, MGL74688, sample A13.
- 5-8 *Sargentina transita* (Kozur 1985). 5, right lateral view, x35, MGL74689, sample A11. 6, left lateral view, x50, MGL74690, sample A19. 7, left lateral view, x50, MGL74691, sample JB43. 8, dorsal view, x50, MGL74692, sample JB43.
- 9-12 *Sargentina woutersi* Crasquin-Soleau n. sp. 9, left lateral view, x35, MGL74693, sample A15. 10, holotype, left lateral view, x35, MGL74694, sample A16A. 11, paratype, dorsal view, x40, MGL74695, sample A16A. 12, right lateral view, x35, MGL74696, sample A13.
- 13-17 *Cavellina huqfensis* Crasquin-Soleau n. sp. 13, left lateral view, x70, MGL74697, sample A11. 14, holotype, left lateral view, x65, MGL74698, sample A18. 15, paratype, left lateral view, x65, MGL74699, sample A11. 16, dorsal view, x65, MGL74700, sample A18. 17, right lateral view, x60, MGL74701, sample A18.
- 18-19 *Healdianella?* 18, left lateral view, x65, MGL74734, sample A11. 19, dorsal view, x60, MGL74735, sample A11.







plained by the importance of an east-west surface current in the Paleotethys realm.

## ACKNOWLEDGMENTS

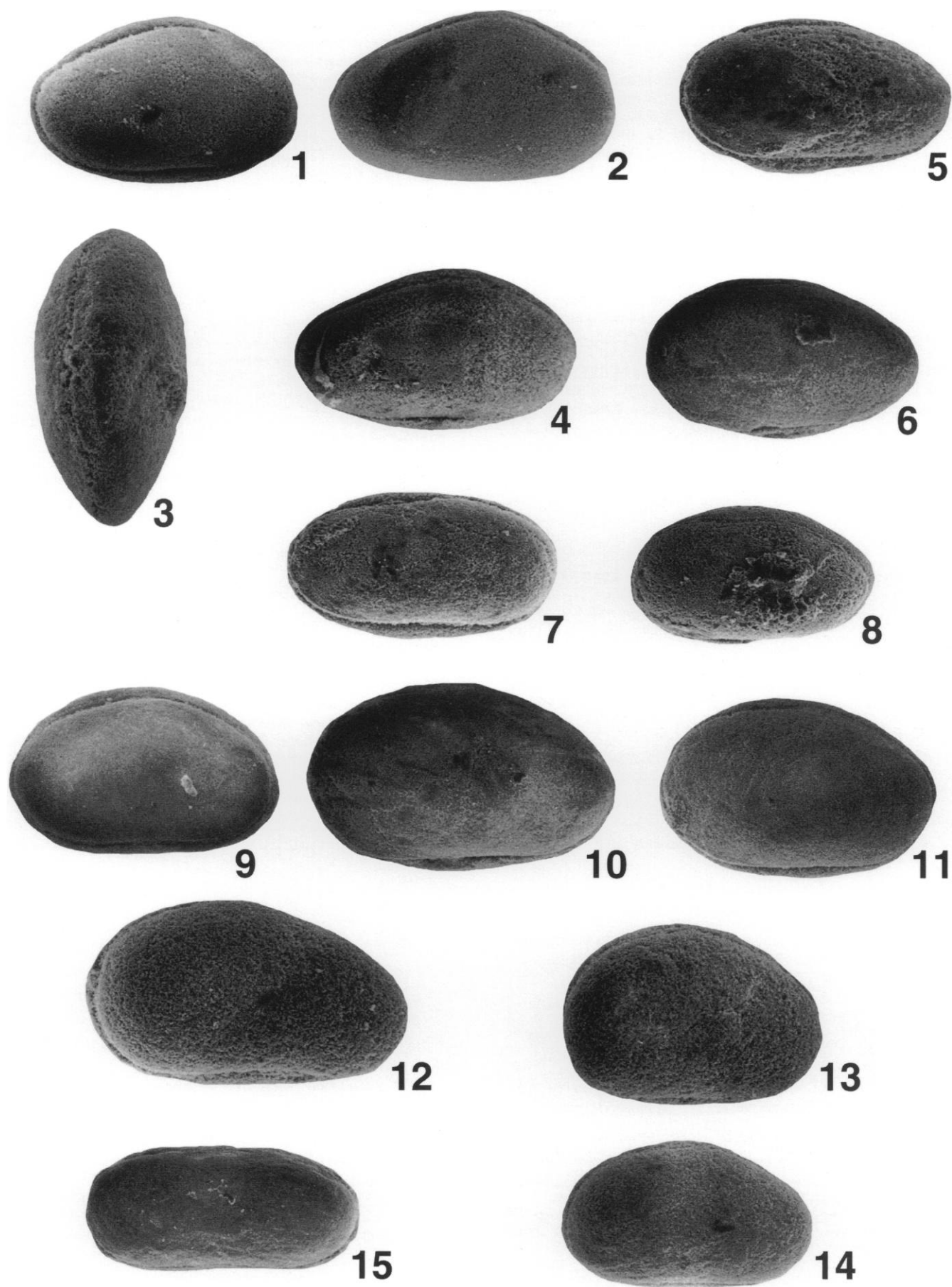
This study is supported by the International Peri-Tethys Programme and the CNRS ESA 7073. We are very grateful to Prof. Alan Lord (University College London) who reviewed the first proof of the paper. We thank Dr. Rosalie Maddocks (University of Houston) and the anonymous reviewer for their constructive remarks and their help to improve the text.

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## PLATE 4

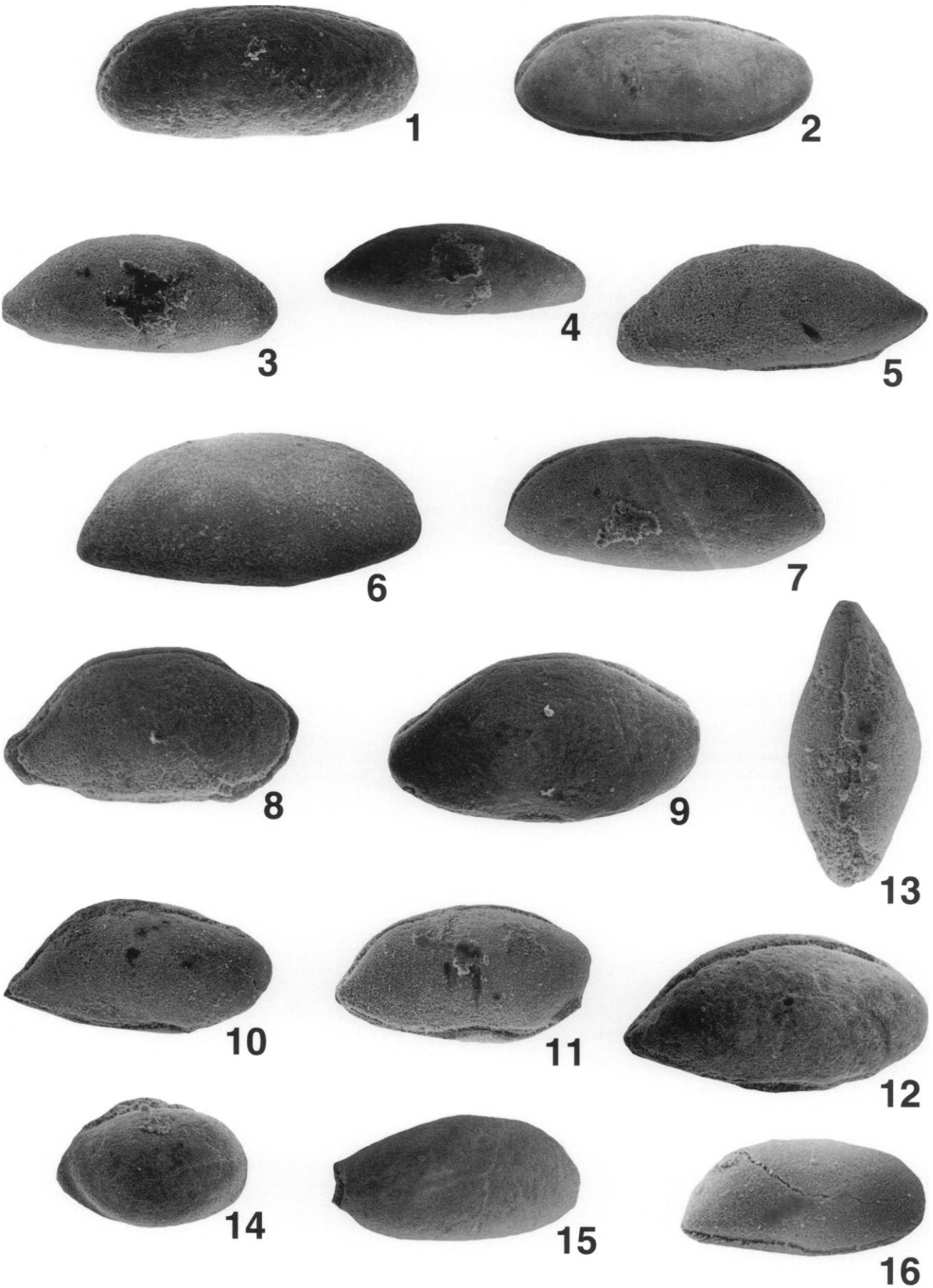
- 1-4 *Cavellina boomeri* Crasquin-Soleau n. sp. 1, holotype, left lateral view, x60, MGL74702, sample A12. 2, paratype, left lateral view, x70, MGL74703, sample A13. 3, dorsal view, x80, MGL74704, sample A38. 4, left lateral view, x60, MGL74705, sample A12.
- 5-6 *Cavellina* n. sp. 4 5, left lateral view, x60, MGL74706, sample A7. 6, left lateral view, x55, MGL74707, sample A35.
- 7-8 *Sulcella sulcata* Coryell and Sample 1932 7, left lateral view, x60, MGL74708, sample A7. 8, left lateral view, x40, MGL74709, sample A7.
- 9-11 *Cavellina gerryi* Crasquin-Soleau n. sp. 9, holotype, left lateral view, x60, MGL74710, sample A18. 10, left lateral view, x55, MGL74711, sample A37. 11, paratype, left lateral view, x50, MGL74712, sample A33B.
- 12-14 *Sulcella arabica* Crasquin-Soleau n. sp. 12, holotype, left lateral view, x75, MGL74713, sample A33B. 13, left lateral view, x65, MGL74714, sample A12A. 14, paratype, left lateral view, x60, MGL74715, sample A33B.
- 15 *Sulcella superpermiana* Kozur 1985, left lateral view, x35, MGL74716, sample JB43.



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## PLATE 5

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| <p>1-2 <i>Fabalicypis parva</i> Wang 1978, 1 right lateral view, X60, MGL74717, sample A23. 2, right lateral view, X35, MGL74718, sample A18.</p> <p>3 <i>Acratia</i> n. sp. 2, right lateral view, X60, MGL74719, sample A23. Note the presence of a tubercule in antero-dorsal part.</p> <p>4-5 <i>Acratia</i> cf. <i>subularis</i> n. sp. 1 4, right lateral view, X35, MGL74720, sample A32. 5, left lateral view, X40, MGL74721, sample A23.</p> <p>6-7 <i>Acratia</i> n. sp. 3 6, right lateral view, X60, MGL74722, sample A27. 7, right lateral view, X60, MGL74723, sample JB43.</p> | <p>8 <i>Bairdia</i> sp. 1 right lateral view, X65, MGL74724, sample A32.</p> <p>9 <i>Bairdia</i> cf. <i>acrisa</i> Stepanaitys 1975, right lateral view, X65, MGL74725, sample JB43.</p> <p>10-13 <i>Bairdia omanensis</i> n. sp. 10, holotype, right lateral view, X35, MGL74726, sample A23. 11, right lateral view, X40, MGL74727, sample A5. 12, paratype, right lateral view, X40, MGL74728, sample A12A. 13, dorsal view, X55, MGL74729, sample A5.</p> <p>14-15 <i>Birdsallella?</i> spp. 14, left lateral view, 30, MGL74730, sample A12A. 15, left lateral view, X35, MGL74731, sample A12A.</p> <p>16 <i>Acratina diffusa</i> Schneider 1959, left lateral view, X90, MGL74732, sample A13.</p> |
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